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Modeling the Growth of Food Science and Technology Literature in India

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Abstract

Purpose: The purpose of the research paper is to find the most appropriate growth model in the field of Food Science and Technology in India.

Design/Methodology/Approach: The Growth rate functions α_1 and α_2 methodology suggested by Egghe and Rao.

Findings: The research shows that Growth of the Food Science and Technology Literature is viable in terms of Publications as well as in Citations.

Research Limitations/ Implications: The research area is limited to Food Science and Technology area in India only.

Originality/Value: The growth rate functions in the field of food science and technology particularly in India is not performed earlier.

Keywords: Scientometrics; Growth Modeling; Growth Rate Functions; Food Science and Technology

1. Introduction

Today India is not only self-sufficient but also exports food and has a reserve because of advances in Food technology. "During the last decade many indigenous developments have taken place in the field of food technology reducing dependence on imported know-how. During these years increased industrialization and its social consequences accelerated the development of food technology. As a result, food industries took birth and shape. Food processing is generally regarded as a traditional industry but advances in microelectronics, instrumentation and control, new materials, bioprocessing and biotechnology beginning to propel the industry at a faster rate"(Srilakshmi, 2006). In present scenario, Indian's food ecosystem offers huge opportunities for investment with growth in food retail sector. "The Government of India through the Ministry of Food Processing Industries (MoFPI) is also taking all necessary steps to boost investments in the food processing industry. The government has sanctioned 42 Mega Food Parks (MFPs) to be set up in the country under the Mega Food Park Scheme. Currently, 17 Mega Food Parks have become functional."(Investindia.gov.in)

2. Review of Literature

Many studies have been carried out to study the best of fit of growth models and some of the prominent studies are mentioned here: Calvino (2006) examined 48 journals of Iberian American (IA) countries in the food science and technology field indexed in Science Citation Index and identified the different patterns of collaboration and growth rate. Zhou et.al. (2013) investigated international collaboration between China and the UK in food and agriculture. They have create new method i.e. Integrated Impact Indicator (I3) to evaluate publication impact. Morooka and Nathaniel (2014) focused on the structure of interdisciplinary in Japanese rice research by using compiled bibliography on Japanese rice which consists of 19389 articles in 1611 journals for the period of 1990-2000. They depicted relationship among disciplines by the frequency distribution of articles among journals based on the law of scattering, identified by Bradford. Seetharam and Rao (1999) tried to trace and compare the growth trends in Food Science and Technology literature produced by Indian

as well as world food scientist for the period between 1950 and 1990. They have tried to identify the best fitting growth models, t and $t \sim 2t$ analysis and compare growth rates. Sharma, Gupta and Kumar (2002), discussed the application of growth models in physics, chemistry, and electrical and electronic engineering research from the international databases of the fields for the period of 1907-1994, using the growth rate functions suggested by the Egghe and Rao. Sangam, Liming and Ganjihal (2010), described the application of growth models in the field of liquid crystals research of Indian and Chinese publications for the period of 1997-2006. The results obtained from the statistical fit of growth models reveals that the power and growth models are fit for the growth of Indian publications and Linear, power and growth models are applicable for the Chinese liquid crystals literature. Gururaj and Gavisiddappa (2015), studied the growth of neurology literature for the period of 1961-2010 on the 291702 records reflected from the Science Direct, using Relative Growth Rate (RGR) and Doubling Time (Dt) to check the growth model of neurology literature. The results shows that neurology literature fits closely to exponential growth model. Gupta, Kumar and Sangam (2002), conducted a study to find the application of growth models in the disciplines of social science namely anthropology, economics, history, political science, psychology, and sociology in the world and to verify the criteria for selecting the most appropriate growth model suggested by Egghe and Rao. They concluded from the study that power model followed by logistic model are describing the best the cumulative growth of publications in the sub disciplines of social science. The study also reveals that growth rate functions methodology supports the results obtained by from the actual applications of models to some extent. Nayak and Bankapur (2017), mapped the growth of the literature published from 1930 to 2016 on agriculture in global and national levels using various scientometric indicators such as Relative Growth Rate (RGR), Doubling time (Dt), Skewness, Kurtosis, Regression, along with different growth models to check the most appropriate growth model of the literature. The results of the study revealed that the world agriculture literature follows the linear and exponential growth model.

3. Objectives of the Study

The study is carried out to achieve the following objectives of the study:

- (i) To find out the pertinence of the growth models to the growth of Indian publications in the area of food science and technology;
- (ii) To verify the basis for selecting the most appropriate growth model from linear, logistics and exponential growth model.

4. Methodology

Web of Science is a core collection of Social Science Citation Index, Science Citation Expanded Index, and Humanities Index. The current study restricted its search strategy to Science Citation Expanded Index with a time frame of 1989-2018 and used subject WC= Food Science & Technology AND CU= India. The search is refined by excluding DOCUMENT TYPES: (CORRECTION OR LETTER OR BOOK CHAPTER OR EDITORIAL MATERIAL OR RETRACTED PUBLICATION OR BOOK REVIEW OR NOTE OR MEETING ABSTRACT OR REPRINT OR SOFTWARE REVIEW OR PROCEEDINGS PAPER. There are other databases dedicated to Food science and Technology i.e. FASTA but instead of that WOS was chosen because the coverage of WOS is much more than FASTA and it covers all the journals which are covered by FASTA as well. Moreover in WC, the field Food Science and Technology is clearly defined. The search was conducted on 12th September 2019 and it produces 16255 data results. The data has been download in excel sheet for further analysis. The analysis have been carried out by using SPSS IBM 22.

The methodology suggested by Egghe and Rao for growth models applied on the data in terms of growth of references on a specific topic, and to identify the model explaining the growth of literature, references by using growth rate functions i.e. α_1 and α_2 (as proposed by Egghe and Rao, 1992). Later the values of two growth rate functions to find the best suitable model of the study. Table 1 is describing the classification of growth models based on the first growth rate function i.e. α_1 and second growth rate functions i.e. α_2 . In order to get the best growth model; growth rates are visualized in terms of classification types, Type-1 increasing; Type-2 constant; Type-3 decreasing; and Type-4 increasing and then decreasing as shown in Table 1.

Table 1: Classification of mathematical growth models based on growth rate functions

| Type of model | First growth rate function | Second growth rate function |
|----------------------------|----------------------------|-----------------------------|
| Exponential | Type II | Type I |
| Logistic | Type III | Type IV |
| Power ($a>0, 0<b\leq 1$) | Type III | Type I |
| Power ($a>0, b>0$) | Type IV | Type I |
| Power ($a=0$) | Type III | Type II |

Type I=Increasing; Type II=Constant; Type III=Decreasing; Type IV=Increasing then Decreasing.

5. Data Analysis

5.1 Growth Modeling of Publications of Food Science and Technology

Table 2 describes the growth of literature of Food science and Technology using two growth rate functions given by Egghe and Rao (1992) during the period of 1989-2018. Two growth rate functions are α_1 and α_2 , where $\alpha_1(t)$ is the first growth rate functions which demonstrates the growth rate after each year and $\alpha_2(2t)$ is the second growth rate function which compares the growth after double time period (from t to $2t$ period).

$$\alpha_1(t) = f(t+1)/f(t)$$

$$\alpha_2(t) = f(2t)/f(t) \text{ for } t = 1, 2, 3, 4$$

The relation between α_1 and α_2 is given by the following equation:

$$\alpha_2(t) = \alpha_1(2t-1) \alpha_1(2t-2) \dots \alpha_1(t) \dots$$

If there are in total N observations (i.e. $t=0, 1, 2, 3, \dots$), there would be $N-1$ values for α_1 and $N/2$ values for α_2 .

Table 2: Growth of Literature of Food Science and Technology in terms of Publications

| S.No. | Year | Number of Publications | Cumulative number of publications | α_1 | α_2 |
|-------|------|------------------------|-----------------------------------|------------|------------|
| 1 | 1989 | 211 | 211 | | |
| 2 | 1990 | 213 | 424 | 2 | 2 |
| 3 | 1991 | 211 | 635 | 1.49 | |
| 4 | 1992 | 230 | 865 | 1.36 | 2.04 |
| 5 | 1993 | 237 | 1102 | 1.27 | |
| 6 | 1994 | 225 | 1327 | 1.2 | 2.08 |
| 7 | 1995 | 216 | 1543 | 1.16 | |
| 8 | 1996 | 226 | 1769 | 1.14 | 2.04 |

| | | | | | |
|----|------|------|-------|------|------|
| 9 | 1997 | 263 | 2032 | 1.14 | |
| 10 | 1998 | 287 | 2319 | 1.14 | 2.1 |
| 11 | 1999 | 309 | 2628 | 1.13 | |
| 12 | 2000 | 337 | 2965 | 1.12 | 2.23 |
| 13 | 2001 | 349 | 3314 | 1.11 | |
| 14 | 2002 | 371 | 3685 | 1.11 | 2.38 |
| 15 | 2003 | 409 | 4094 | 1.11 | |
| 16 | 2004 | 458 | 4552 | 1.11 | 2.57 |
| 17 | 2005 | 469 | 5021 | 1.1 | |
| 18 | 2006 | 572 | 5593 | 1.11 | 2.75 |
| 19 | 2007 | 698 | 6291 | 1.12 | |
| 20 | 2008 | 658 | 6949 | 1.1 | 2.99 |
| 21 | 2009 | 689 | 7638 | 1.09 | |
| 22 | 2010 | 804 | 8442 | 1.1 | 3.21 |
| 23 | 2011 | 795 | 9237 | 1.09 | |
| 24 | 2012 | 791 | 10028 | 1.08 | 3.38 |
| 25 | 2013 | 830 | 10858 | 1.08 | |
| 26 | 2014 | 1077 | 11935 | 1.09 | 3.6 |
| 27 | 2015 | 1256 | 13191 | 1.1 | |
| 28 | 2016 | 975 | 14166 | 1.07 | 3.84 |
| 29 | 2017 | 1075 | 15241 | 1.07 | |
| 30 | 2018 | 1014 | 16255 | 1.06 | 3.97 |

It is observed from the table 2, figure 1 and figure 2 as well, that α_1 is showing decreasing trend as it decreases till 1.06 in 2018 which is 2 in 1990 whereas α_2 is showing increasing trend over the years. It indicates the suitability of Power model on the growth of food science and technology literature as it showing the $a > 0$, $0 < b \leq 1$, specifications. However all the three models i.e. exponential model, power model, and logistic model on observed data of the Food science and technology area, using curve estimation method. On the basis of Cumulated publications we have plot the graph figure 3,4 and 5 respectively for all the growth models i.e. Exponential, Logistics, and Power using SPSS IBM 22 version.

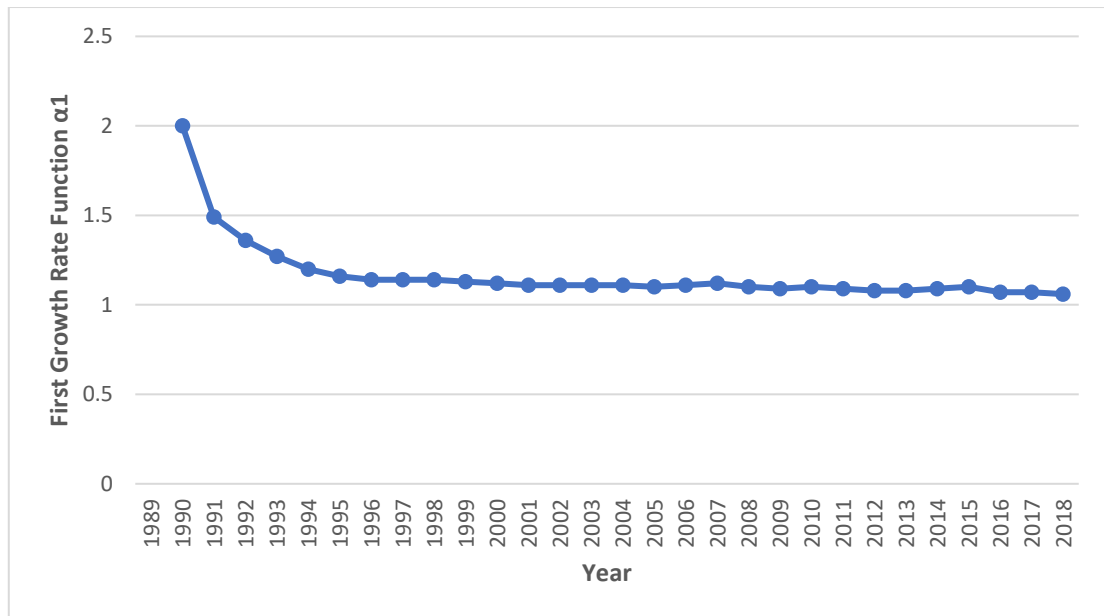


Figure1: Graphical Presentation of First Growth Rate Function for α_1

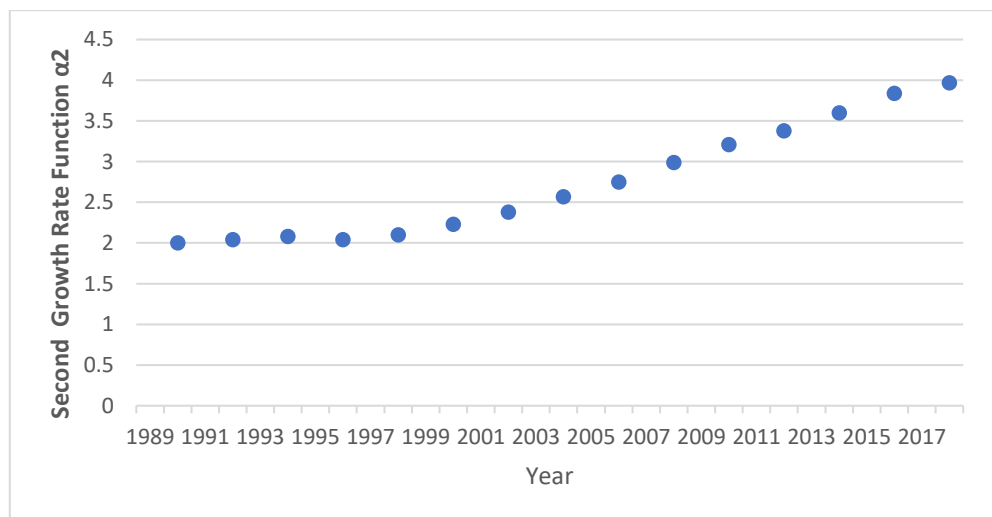


Figure 2: Graphical Presentation of Second Growth Rate Function for α_2

Table 3: Parameter Values and Fit Statistics Obtained from Application of Various Growth Model on Food Science and Technology Literature

| Model | Parameters values | | Fit Statistics | | Doubling Time |
|-------------|-------------------|---------|----------------|---------|---------------|
| | a | b | R^2 | F | |
| Exponential | 2.40E-105 | 0.124 | 0.942 | 457.116 | 5 Years |
| Logistic | 4.150E+104 | 0.883 | 0.942 | 457.116 | |
| Power | 0.000 | 249.187 | 0.943 | 463.350 | |

Table 3 depicts the parameter values and fit statistics obtained from the application of various growth models on Food Science and Technology Literature. The R^2 , indicates the range of variation explained in the model, for Exponential, Logistics and Power growth

models is observed as 0.942, 0.942 and 0.943 respectively. So, it can be observed from the values that the growth of the Food Science and Technology Literature can be explained from any of the mentioned models. However, Doubling Time is the period of time required for a quantity to double in size or value.

Doubling time and Relative Growth Rate has a direct relation between them. The Relative Growth Rate (RGR) is the increase in number of articles or pages per unit of time. The mean relative growth rate (R) over the specific period of interval can be calculated from the following equation:

$$1 - 2R = \frac{\text{Loge}W2 - \text{Loge}W1}{T2 - T1}$$

Where,

1 - 2R – Mean relative growth rate over the specific period of interval

LogeW1 – log of initial number of articles

LogeW2 – log of final number of articles after a specific period of interval

T2-T1 – Unit difference between the initial time and the final time

$$\begin{aligned} \text{RGR} &= (t_2 - t_1) = \ln(16255) - \ln(211) / 29 - 0 \\ &= 0.14 \end{aligned}$$

$$\begin{aligned} \text{Dt} &= \ln(2) / R \\ &= 0.693 / 0.14 \\ &= 4.95 \sim 5 \text{ years} \end{aligned}$$

The computed value of Doubling Time indicates that 5 years is an approx. time period required to double the literature in the area of Food Science and Technology.

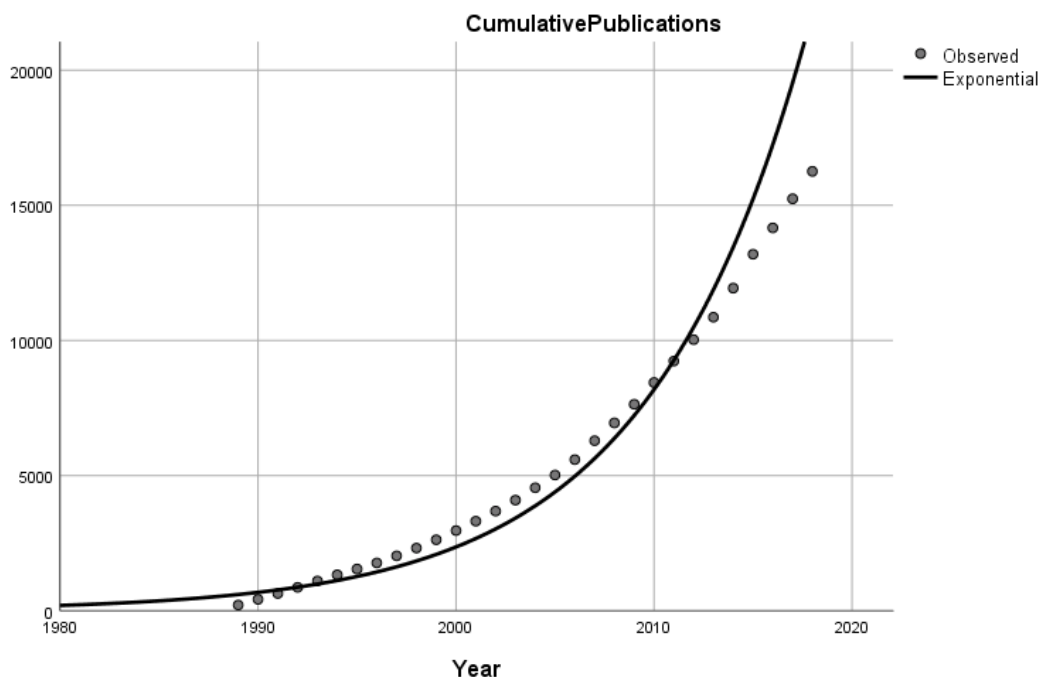


Figure 3: Exponential Curve Estimation for the Cumulative Publications of Food Science Literature

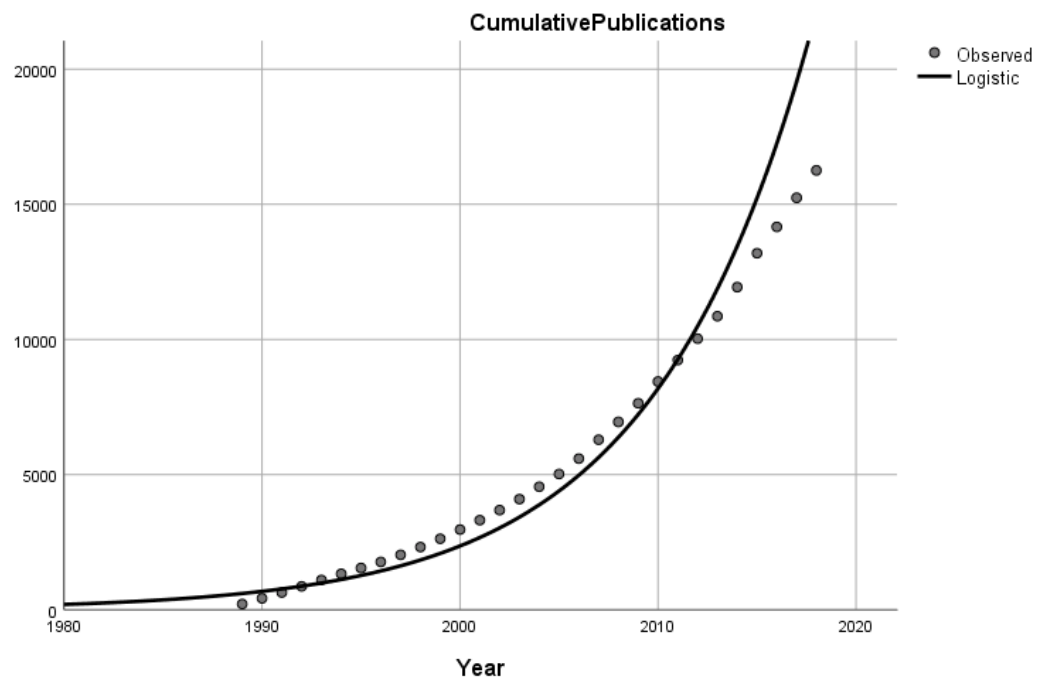


Figure 4: Logistics Curve Estimation for the Cumulative Publications of Food Science Literature

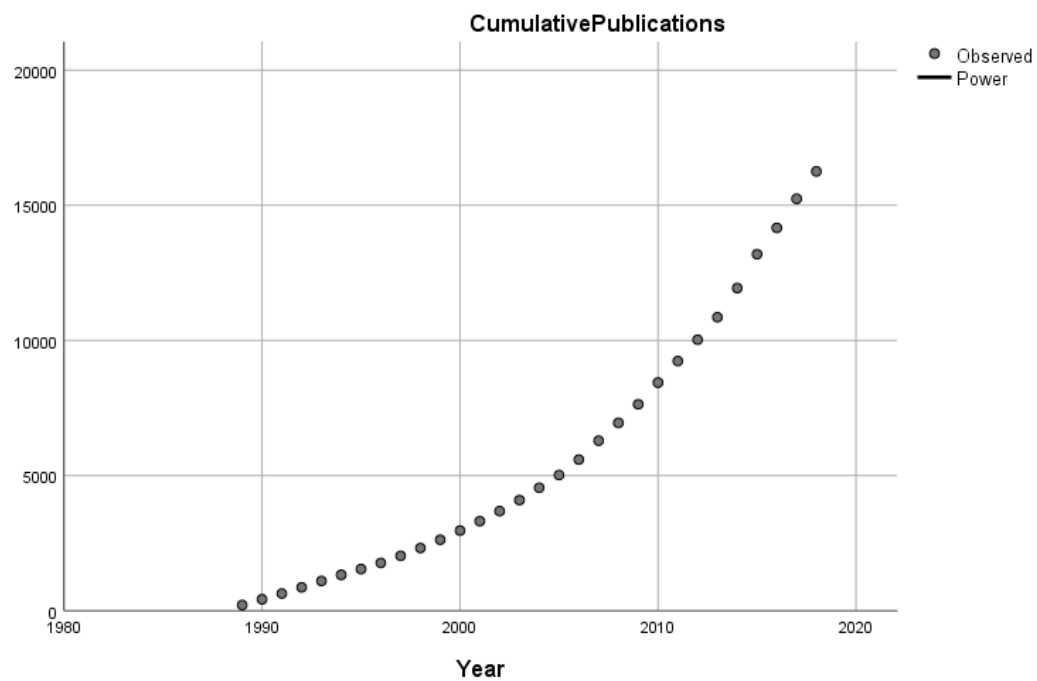


Figure 5: Power Curve Estimation for the Cumulative Publications of Food Science Literature

5.2 Growth of Citations

Table 4: Growth of Citations in Food Science and Technology

| S.No. | Year of Publications | Number of Citations | Cumulative Number of Citations | $\alpha 1$ | $\alpha 2$ |
|-------|----------------------|---------------------|--------------------------------|------------|------------|
| 1 | 1989 | 2479 | 2479 | | |
| 2 | 1990 | 2085 | 4564 | 1.84 | 1.84 |
| 3 | 1991 | 2250 | 6814 | 1.49 | |
| 4 | 1992 | 2241 | 9055 | 1.32 | 1.98 |
| 5 | 1993 | 2446 | 11501 | 1.27 | |
| 6 | 1994 | 2534 | 14035 | 1.22 | 2.05 |
| 7 | 1995 | 2586 | 16621 | 1.18 | |
| 8 | 1996 | 3388 | 20009 | 1.2 | 2.2 |
| 9 | 1997 | 3948 | 23957 | 1.19 | |
| 10 | 1998 | 4442 | 28399 | 1.18 | 2.46 |
| 11 | 1999 | 5224 | 33623 | 1.18 | |
| 12 | 2000 | 4894 | 38517 | 1.14 | 2.74 |
| 13 | 2001 | 7841 | 46358 | 1.2 | |
| 14 | 2002 | 9239 | 55597 | 1.19 | 3.34 |
| 15 | 2003 | 10076 | 65673 | 1.18 | |
| 16 | 2004 | 10674 | 76347 | 1.16 | 3.81 |
| 17 | 2005 | 11422 | 87769 | 1.14 | |
| 18 | 2006 | 15375 | 103144 | 1.17 | 4.3 |
| 19 | 2007 | 20594 | 123738 | 1.19 | |
| 20 | 2008 | 13856 | 137594 | 1.11 | 4.84 |
| 21 | 2009 | 15155 | 152749 | 1.11 | |
| 22 | 2010 | 17576 | 170325 | 1.11 | 5.06 |
| 23 | 2011 | 15859 | 186184 | 1.09 | |
| 24 | 2012 | 14312 | 200496 | 1.07 | 5.2 |
| 25 | 2013 | 12329 | 212825 | 1.06 | |
| 26 | 2014 | 13239 | 226064 | 1.06 | 4.87 |
| 27 | 2015 | 13444 | 239508 | 1.05 | |
| 28 | 2016 | 8336 | 247844 | 1.03 | 4.45 |
| 29 | 2017 | 4904 | 252748 | 1.01 | |
| 30 | 2018 | 2373 | 255121 | 1 | 3.88 |

It is observed from the table 4, figure 6 and figure 7 as well, that $\alpha 1$ is showing decreasing trend as it decreases till 1 in 2018 whereas $\alpha 2$ is showing increasing trend over the years, as it reaches to 3.88 in 2018. It indicates the suitability of Power model on the growth of food science and technology literature as it showing the $a > 0$, $0 < b \leq 1$, specifications. However all the three models i.e. exponential model, power model, and logistic model on observed data of the Food science and technology area, using curve estimation method. On the basis of Cumulated Citations we have plot the graph figure 8, 9 and 10 respectively for all the growth models such as Exponential, Logistics, and Power using SPSS IBM 22 version.

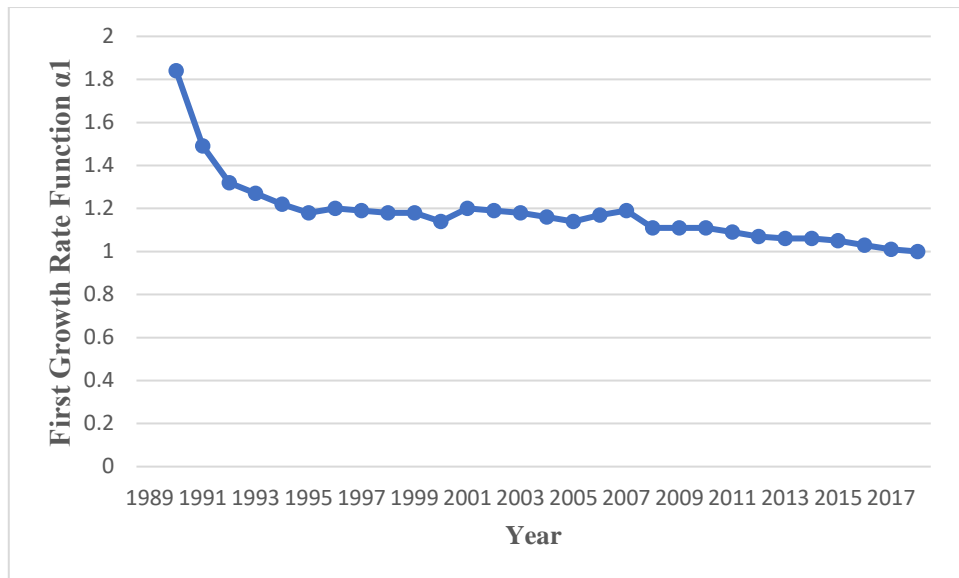


Figure 6: Graphical Presentation of First Growth Rate Function for α_1

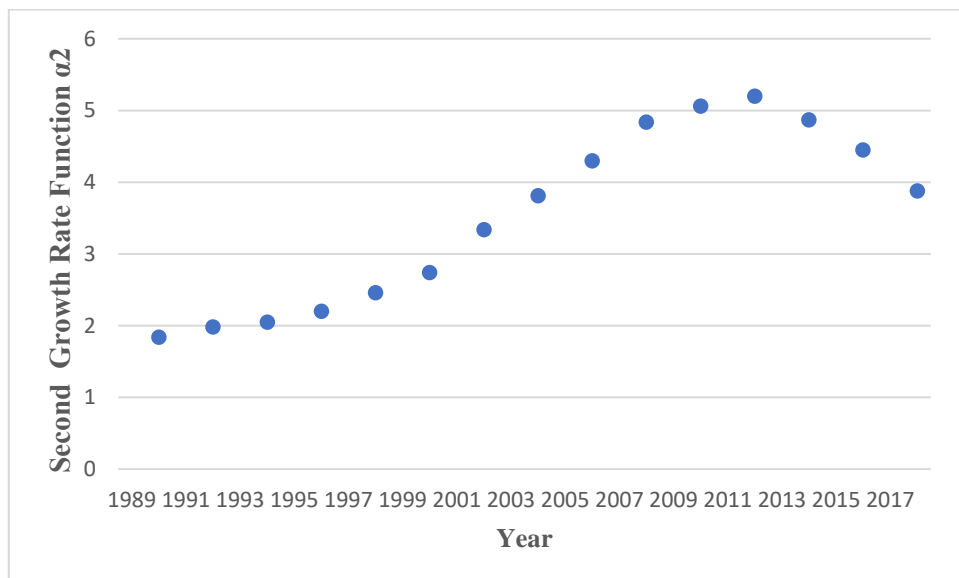


Figure 7: Graphical Presentation of Second Growth Rate Function for α_2

Table 4: Parameter Values and Fit Statistics Obtained from Application of Various Growth Model on Food Science and Technology Literature Citations

| Model | Parameters values | | Fit Statistics | | Doubling Time |
|-------------|-------------------|---------|----------------|---------|---------------|
| | a | b | R^2 | F | |
| Exponential | 2.335E-125 | 0.49 | 0.948 | 515.320 | 5 Years |
| Logistic | 4.283E+124 | 0.862 | 0.948 | 515.320 | |
| Power | 0.0000 | 238.002 | 0.949 | 523.980 | |

Table 4 depicts the parameter values and fit statistics obtained from the application of various growth models on Food Science and Technology Literature Citations. The R^2 , indicates the range of variation explained in the model, for Exponential, Logistics and

Power growth models is observed as 0.948, 0.948 and 0.949 respectively. So, it can be observed from the values that the growth of the Food Science and Technology Literature Citations can be explained from any of the mentioned models. However, Doubling Time is the period of time required for a quantity to double in size or value, which is observed as 5 years of the studying data.

$$\begin{aligned} \text{RGR} &= (t_2 - t_1) = \ln(255121) - \ln(2479) / 29 - 0 \\ &= 12.44 - 7.81 / 29 \\ &= 0.15 \end{aligned}$$

$$\begin{aligned} \text{Doubling Time} &= \ln(2) / R \\ &= 0.693 / 0.15 \\ &= 4.62 \sim 5 \text{ Years} \end{aligned}$$

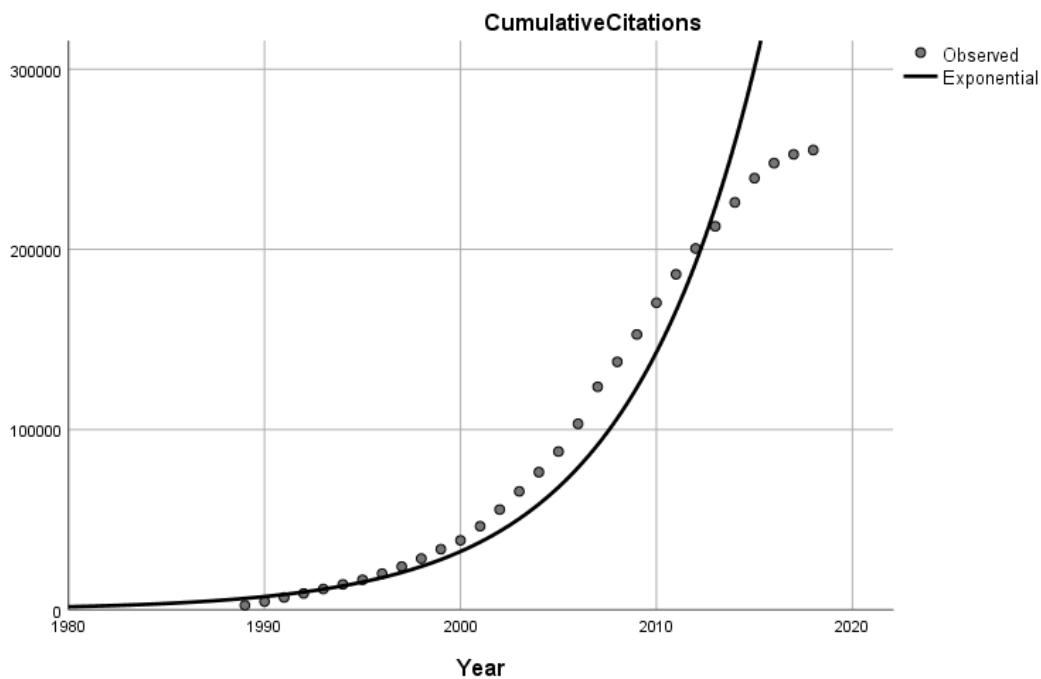


Figure 8: Exponential Curve Estimation for the Cumulative Publications of Food Science Literature Citations

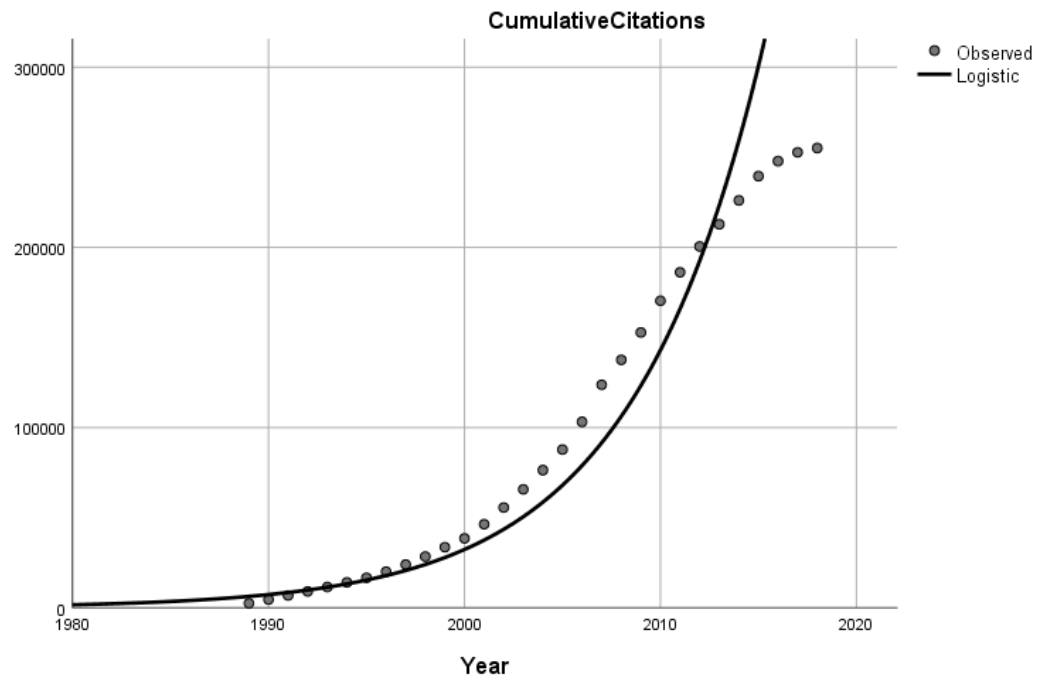


Figure 9: Logistic Curve Estimation for the Cumulative Publications of Food Science Literature Citations

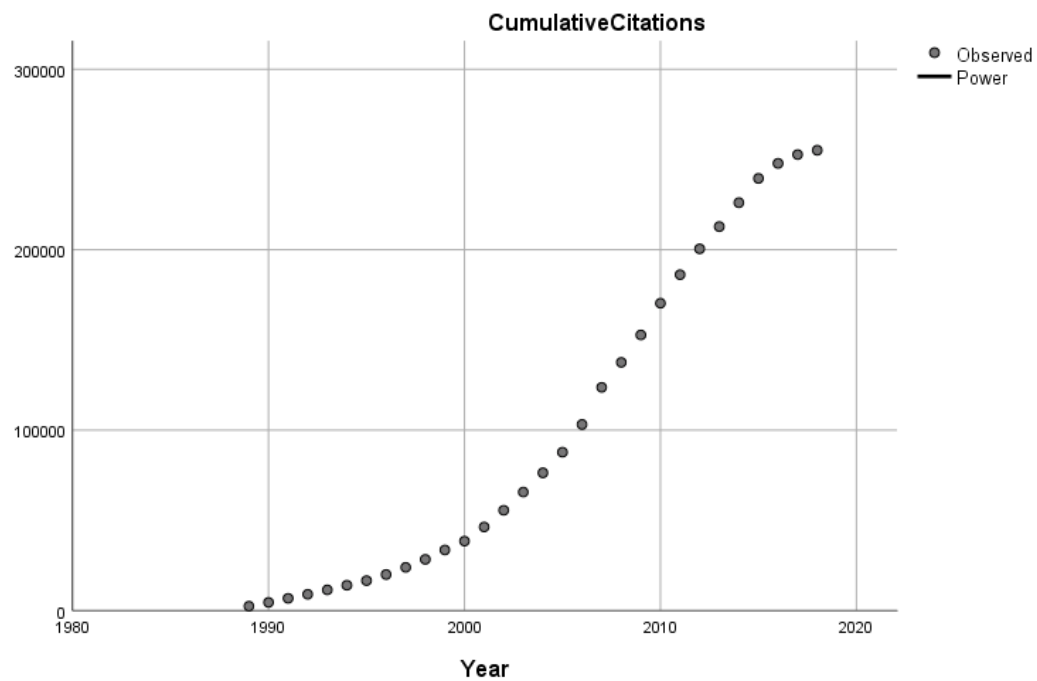


Figure 10: Power Curve Estimation for the Cumulative Publications of Food Science Literature Citations

6. Conclusion

The Modeling of growth study is been done to identify the nature of the growth of literature in any particular field by using various growth models such as Exponential, Logistics, and Power. Growth Rate functions methodology using α_1 and α_2 devised by Egghe and Rao (1992) which is derived by using mathematical formula. Although this methodology is not upto the mark to explain the best fit of the model but till date it is following. There is a need of more analysis to determine the methodology for the best fit model for any literature. The present study is carried out to determine the best fit model in the field of Food Science and Technology. It has been observed that in case of Publications as well as citations all the models can explain the growth of literature and citations. So, it can be concluded that there is viable growth in the Food Science and Technology field.

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